

WHAT IS CLAIMED IS:

1                   1.       A translation lookaside buffer system for translating virtual addresses  
2 to physical addresses, the system comprising:  
3                   an input arbitration module configured to receive translation requests from a  
4 plurality of clients, each translation request including a target virtual address, the input  
5 arbitration module further configured to select one of the translation requests for processing;  
6                   a primary cluster store having a plurality of locations, each location configured  
7 to store a cluster, wherein each cluster provides a mapping to a respective physical address  
8 for each virtual address in a range of virtual address space, and wherein the respective ranges  
9 of different ones of the clusters have different sizes;  
10                  a primary lookup logic circuit coupled to receive the selected translation  
11 request from the input arbitration circuit and configured to associate one of the locations in  
12 the primary cluster store with the selected translation request, thereby designating the  
13 associated location for storing a cluster whose range includes the target virtual address; and  
14                  a translation module configured to translate the target virtual address of the  
15 selected translation request to a physical address based at least in part on the mapping  
16 provided by the cluster stored in the primary cluster store location associated with the  
17 selected translation request.

1                   2.       The translation lookaside buffer system of claim 1, further comprising:  
2                   a primary tag store coupled to the primary lookup logic circuit and configured  
3 to store a tag corresponding to each location in the primary cluster store, wherein each tag  
4 encodes the range of the virtual address space mapped by the cluster in the corresponding  
5 primary cluster store location,  
6                   wherein the primary lookup logic circuit is further configured to detect a  
7 primary cluster hit in the event that the target virtual address of the selected translation  
8 request matches one of the tags in the primary tag store and to detect a primary cache miss  
9 otherwise.

1                   3.       The translation lookaside buffer system of claim 2, wherein each of the  
2 plurality of clients is allocated a non-overlapping portion of the primary tag store.

1                   4.       The translation lookaside buffer system of claim 3, wherein one of the  
2 plurality of clients generates translation requests for a plurality of address streams, and

3 wherein the portion of the primary tag store allocated to the one of the clients is subdivided  
4 among the address streams.

1 5. The translation lookaside buffer system of claim 2, wherein the  
2 primary lookup logic circuit is further configured to respond to a primary cache hit by  
3 associating the location in the primary cluster store that corresponds to the matched tag with  
4 the selected translation request.

1 6. The translation lookaside buffer system of claim 5, further comprising  
2 a secondary cluster cache configured to respond to a detected primary cache miss by  
3 obtaining a cluster based on the target virtual address and storing the obtained cluster in the  
4 primary cluster store.

1 7. The translation lookaside buffer system of claim 6, wherein the  
2 secondary cluster cache includes:  
3 a secondary cluster store configured to store a plurality of clusters;  
4 a secondary tag store configured to store a secondary tag corresponding to  
5 each cluster stored in the secondary cluster store, wherein each secondary tag encodes a range  
6 of virtual addresses mapped by the corresponding cluster; and  
7 a secondary lookup logic circuit configured to receive the target virtual  
8 address and to identify a matching one of the secondary tags in the secondary tag store,  
9 wherein the range of virtual addresses encoded by the matching secondary tag includes the  
10 current target virtual address.

1 8. The translation lookaside buffer system of claim 7, wherein the  
2 secondary cluster cache further includes:  
3 a cluster fetch circuit configured to receive the target virtual address in the  
4 event that a matching secondary tag is not identified by the secondary lookup logic circuit  
5 and to obtain a cluster corresponding to the target virtual address from a cluster table.

1 9. The translation lookaside buffer system of claim 7, wherein a non-  
2 overlapping portion of the secondary tag store is allocated to each client.

1 10. The translation lookaside buffer system of claim 2, wherein the  
2 primary lookup logic circuit is further configured to store a new primary tag for the current  
3 target address in the primary tag store in the event of a primary cache miss, thereby

designating a location in the primary cluster cache for storing a new cluster corresponding to the new primary tag, wherein the new primary tag encodes a minimum-size range of the virtual address space.

11. The translation lookaside buffer system of claim 10, wherein upon storing the new cluster in the primary cluster cache, the new primary tag is updated to reflect the range of virtual addresses for which the new cluster provides a mapping.

12. The translation lookaside buffer system of claim 1, further comprising a buffer module configured to receive translation requests from the primary lookup logic circuit and to store the received translation requests for subsequent forwarding to the translation module.

13. The translation lookaside buffer of claim 12, wherein the primary lookup logic circuit is further configured to process a selected translation request before the cluster for a previously selected translation request is present in the primary cluster store location associated with the previously selected translation request.

14. The translation lookaside buffer system of claim 12, wherein the buffer module includes a separate request queue for each of the plurality of clients.

15. The translation lookaside buffer system of claim 14, wherein the request queues are configured such that a sequential order of receipt among translation requests from a same one of the clients is preserved and a sequential order of receipt among translation requests from different ones of the clients is not preserved.

16. The translation lookaside buffer system of claim 12, further comprising:  
a ready logic circuit configured to identify as a ready request at least one translation request stored in the buffer module for which a cluster is present in the associated location in the primary cluster cache; and  
a selection circuit configured to select one of the ready requests and to provide the selected ready request to the translation module.

1                   17.     The translation lookaside buffer system of claim 1, wherein the input  
2 arbitration module is further configured to select a translation request based at least in part on  
3 availability of downstream resources needed to process each translation request.

1                   18.     The translation lookaside buffer system of claim 17, wherein the  
2 needed downstream resources include a storage location in the primary cluster store.

1                   19.     The translation lookaside buffer of claim 17, wherein the input  
2 arbitration module is further configured to determine whether the needed downstream  
3 resources are available or not available based at least in part on which of the clients generated  
4 the proposed request.

1                   20.     The translation lookaside buffer system of claim 1, wherein the  
2 translation requests received from the clients include a first request from a first one of the  
3 clients, the first request having a transparent translation mode, and wherein the system further  
4 comprises:

5                   a memory interface circuit configured to transmit a memory access request  
6 corresponding to the first request to a system memory device, the memory access request  
7 including the physical address provided by the translation module in response to the first  
8 request.

1                   21.     The translation lookaside buffer system of claim 20, wherein the  
2 translation requests received from the clients further include a second request from a second  
3 one of the clients, the second request having a visible translation mode, and wherein the  
4 memory interface circuit is further configured to transmit to the second client the physical  
5 address provided by the translation module in response to the second request.

1                   22.     A method for translating virtual addresses to physical addresses, the  
2 method comprising the acts of:  
3                   defining a plurality of clusters, wherein each cluster provides a mapping to a  
4 respective physical address for each virtual address in a range of virtual address space, and  
5 wherein respective sizes of the ranges mapped by different ones of the clusters are different;  
6                   receiving a first translation request from a client, the first translation request  
7 including a first target virtual address;

8 storing a first tag in a tag store, the first tag encoding a minimum size range of  
9 the virtual address space that includes the first target virtual address, the first tag further  
10 identifying a first location in a primary cluster store;  
11 associating the first request with the first location in the primary cluster store;  
12 fetching a first cluster that maps a range of the virtual address space that  
13 includes the first target virtual address into the first location in the primary cluster store; and  
14 translating the first target virtual address to a physical address based at least in  
15 part on the mapping provided by the first cluster.

1 23. The method of claim 22, wherein the act of fetching the first cluster  
2 includes the acts of:  
3 searching for the corresponding cluster in a secondary cluster cache based on  
4 the target virtual address; and  
5 in the event that the corresponding cluster is not found in the secondary cluster  
6 cache, fetching the corresponding cluster from a cluster table.

1 24. The method of claim 22, further comprising the act of:  
2 subsequently to storing the first tag, modifying the first tag to encode the range  
3 of the virtual address space mapped by the first cluster.

1 25. The method of claim 22, further comprising the acts of:  
2 subsequently to receiving the first translation request, receiving a second  
3 translation request from the client, the second translation request including a second target  
4 virtual address;  
5 determining whether the second target virtual address matches the first tag;  
6 and  
7 in the event that the second target virtual address matches the first tag:  
8 associating the second request with the first location in the primary  
9 cluster store;  
10 retrieving the first cluster from the first location in the primary cluster  
11 store; and  
12 translating the second target virtual address to a physical address based  
13 at least in part on the mapping provided by the first cluster.

1 26. The method of claim 22, further comprising:

2                   determining whether the first translation request is in a transparent translation  
3   mode or a visible translation mode;  
4                   in the event that the first translation request is in the transparent translation  
5   mode, transmitting a corresponding memory access operation to a system memory device,  
6   wherein the corresponding memory access operation includes the translated physical address;  
7   and  
8                   in the event that the first translation request is in the visible translation mode,  
9   transmitting the translated physical address to the client.